DOCUMENT RESUME

ED 082 505 EM 011 476

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TITLE Effects On Achievement from Programmed Instruction of Experimentally Induced Familiarization of Content and Different Response Modes. Final Report.
INSTITUTION City Univ. of New York, N.Y. Office of Teacher Education.
SPONS AGENCY National Center for Educational Research and Development (DHEW/OE), Washington, D.C. Regional Research Program.
BUREAU NO BR-2-B-012
PUB DATE Sep 73
NOTE 54p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Achievement; Educational Research; Graduate Students; *Intelligence Differences; *Intermode Differences; Junior High School Students; Learning Theories; *Programed Instruction; *Response Mode; *Sex Differences
IDENTIFIERS Advance Organizers; ATI; *Attribute By Treatment Interaction; Familiarity

ABSTRACT

A study of programed instruction sought to establish an attribute by treatment interaction (ATI) between prior familiarity of material and response mode. Two experimental variables (familiarization and response mode) and two subject attributes (sex and I.Q.) were employed. Junior High (JH) and graduate student (GS) were assigned to familiarization (F) or non-familiarization (NF) groups, and to constructed response (CR) or reading (R) modes. The F group received advance familiarizing materials. Main effects for the college data were insignificant, but sex and I.Q. were significant for JH Students. There was ATI between familiarity and response mode. F. led to increased achievement for the R group, but to decreased achievement for the CR group. The familiarity-by-response mode interaction was complicated by interacting with sex for GS and I.Q. for JH. Delayed posttest interactions were more significant than immediate results. The negative effect of F on CR achievement was felt due to lower motivation for able students to attend to familiar material. Sex results were explained by the hypothesis that passive females attend to all tasks, impulsive males only to interesting ones; thus F led to reduced male achievement. Increased retention over time was interpreted as reflecting that retention is a function of initial meaningful learning. (Author)

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FINAL REPORT
Project No. 2-B-012
Grant No. OEG-2-22B012

EFFECTS ON ACHIEVEMENT FROM PROGRAMMED INSTRUCTION OF EXPERIMENTALLY INDUCED FAMILIARIZATION OF CONTENT AND DIFFERENT RESPONSE MODES

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The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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Summary

The aim of this study of Programmed Instruction (PI) was to establish an attribute by treatment interaction (ATI) between prior familiarity of the material to be learned and response mode. No study has been found which tests the effects of familiarity of subject matter by starting with material unfamiliar to all Ss and experimentally inducing a degree of prior familiarization. To do so, two experimentally manipulated variables (familiarization and response mode) and two subject attributes (sex and intelligence as measured by an I.Q. test score) were employed.

Two distinct samples of Ss participated. Totals of 110 junior high school students and 59 graduate students were randomly assigned to a familiarization or non-familiarization group, and to one of two response modes: constructed response or reading. The learning materials consisted of a linear program dealing with the diagnosis of myocardial infarction, a technical medical program unfamiliar to Ss prior to studying the program. The familiarization group was given familiarizing material including technical terms before beginning the learning program. An immediate posttest was administered directly after the program and a delayed posttest was administered one week later.

Data were analyzed by multiple linear regression. None of the main effects for the college data was consistently significant but both sex and I.Q. were significant for the junior high school Ss. There was a consistent ATI between familiarity and response mode; prior familiarization led to increased achievement for the reading group, as hypothesized, but unexpectedly led to decreased achievement for the constructed response (CR) group. The familiarity x response mode interaction was further complicated by interacting with sex for the college Ss and I.Q. for the junior high school Ss.

On the delayed posttest the interactions were more significant than on the immediate posttest. Previous findings regarding the greater amount of time spent on the CR program than on the reading version of the program were replicated. The CR groups took half the time of the reading groups on the immediate posttest, and equal amounts of time on the delayed posttest.

The finding that prior familiarization had a negative effect on achievement from CR was interpreted in terms of attention-motivation. The college Ss and the high-I.Q. junior high school Ss were superior learners; they reacted unfavorably to a program that forced responding to material with which they were already familiar. The sex results were explained using Maccoby's female-passive, male-impulsive model of cognitive differences between the sexes. The females continued to attend to their task whether interested or not, while the males attended only if interested in the task at hand. Thus, pre-familiarization led to reduced male achievement. The sharpening of differences over the retention interval was interpreted in terms of Ausubel's theory of meaningful learning where retention is a function of initial learning. The familiarity x response mode interaction needs further investigation, as the present study led to no consistent theoretical interpretations. Suggestions consistent with the findings of this study are made concerning instructional methodology.

Introduction

The use of linear programmed instruction (LPI) as a teaching tool is of general importance to education. The typical LPI format consists of a sequence of bits of information (frames) to which the student is to respond in overt (written) rather than covert (reading) fashion. The LPI theory is that requiring overt responses forces attention to the material. Thus promoting more learning than would be expected from the absence of control over attention under covert responding. However, previous investigations of the effects of response mode on learning have generally failed to show significant differences. Later research has been interpreted to suggest that constructing responses leads to higher achievement for technical, unfamiliar material though no differences are found for familiar material. A similar distinction between achievement on complex problem solving skills resulting from exposure to "scrambled" and ordered-sequence frames has been reported although no such difference for less complex tasks has been found.

A promising interpretation of the above discrepancies has been formulated (Tobias & Abramson, 1970); namely, that acquisition or learning from LPI will not be differentially affected by the response mode <u>if</u> the material to be learned was within the <u>S</u>'s response repertory before his exposure to the program. If, on the other hand, the information to be learned is <u>new</u> to the <u>S</u>, then overt, constructed responses should be superior to other modes of responding to the materials. By experimentally manipulating the amount of prior familiarity it should be possible to study the differential effects of prior familiarity on the mode of responding (overt vs. covert). The aim of the present report was to study the hypothesized interaction between prior familiarity and response mode.

Review of the Literature

One of the basic assumptions of LPI is that, for maximum learning, it is essential for the student to construct his responses as he progresses through the instructional program. Earlier research dealing with the question of the effects of varying the response mode on achievement from LPI have not confirmed the hypothesized difference (Anderson, 1967; Tobias, 1968). Achievement was comparable if the S constructed (overt), "thought" (covert), selected (multiple choice), or read his response.

Tobias and Abramson (1970) suggested that there is an interaction between response mode and the Ss prior familiarity with the material to be learned. They hypothesized that overt responding would produce higher achievement if the material to be learned was new to the S and that there would be no difference in achievement between Ss exposed to different response modes for material with which the Ss were already familiar. A plausible explanation for the failure to find superiority for the constructed response mode is that Ss were already familiar with the material to be learned before beginning their instfuctional program.

This "familiarity" interpretation arose from two earlier studies (Tobias, 1969a, 1969b) in which the Ss were exposed to an LPI dealing with heart disears which contained both technical, relatively unfamiliar content, as well as material with which the Ss had a good deal of prior familiarity. Both studies found no difference in achievement between overt and covert responding on the familiar material and found significant differences between the groups on the technical, unfamiliar portion of the program. A number of other studies seem to support the familiarity x response mode interaction hypothesis. Studies by Cummings and Goldstein

(1962) and Williams (1963, 1965) concluded that the overt response mode was superior when the Ss were exposed to "technical" material. Technical in these studies could be taken to mean that the Ss had little prior familiarity with the material contained in the program they were to learn. In a similar vein, Karis, Gilbert and Kent (1968) found that constructed responses led to superior achievement on a medical program when the technically acceptable terminology was required. When non-technical synonyms were accepted as correct responses, no differences in achievement due to response mode were found.

Nuthall (1968) used four different constructed response programs to test for differences associated with teaching strategy. Although there were no reliable effects resulting from the different teaching strategies employed, the data tended to favor a familiarity by teaching strategy interaction. Even with only one response mode familiarity remained an important variable.

Two studies which used Holland and Skinner's (1961) program and non-programmed versions of the same material also tend to support the familiarity interpretation. Daniel and Murdoch (1968) used a multivariate analysis and indicated that the greater achievement for the programmed group could be interpreted as contingent on prior knowledge of operant conditioning. Roderick and Anderson (1968) compared achievement from the program with achievement resulting from textbook-like material of the same content. They found that the program led to greater achievement for high school seniors, but not for college Ss in educational psychology. Since general psychology is frequently a prerequisite for educational psychology, it is probable that the college Ss had some familiarity with the concepts of operant conditioning prior to exposure to the program. This was probably

likely not the case for the high school Ss.

Payne, Krathwohl and Gordon (1967) found no difference in achievement between Ss exposed to a logical and a randomly sequenced program. They suggested that the Ss may have had more prior knowledge of the material than was originally expected. In a study of the effect of sequence on transfer, Neidermeir (1968) found no difference either in transfer or achievement. However, the differences on the simpler, more common materials were smaller than on the more technical, more unfamiliar subject matter. Brown (1970) found that bright, relatively mature tenth- and eleventh-grade mathematics students did better on complex problem solving skills resulting from a logically sequenced program than from a scrambled version of the same program. These findings were discussed in terms of Gagne's (1968) hierarchy of task structure in which the complex task is considered to be highly specialized and contingent on transfer from subordinate tasks and thus not subject to solution through the application of a more general strategy. A more parsimonious interpretation would be that the less familiar the material to be learned, the greater the effect of variables such as sequence, feedback, and response mode on achievement from LPI. This is particularly so if one defines complexity as an inverse function of familiarity--the more familiar the less complex and vice versa. (Of course, in general, it is also possible to define complexity so that a task is both familiar and complex.)

Grotelueschen and Sjorgen (1968) in their studies of the facilitative effects of advance organizers on the learning and transfer of Ss who had little or no familiarity with the subject being learned, suggested that the complexity of the learning task should be considered in evaluating the learning that occurred. Their suggestion arose because they found a

facilitative effect for Ss of superior intelligence, whereas Ausubel and Fitzgerald (1961) found a facilitative effect for Ss of low verbal ability. In line with the argument presented above, it may well be that the crucial variable is the prior familiarity of the S with the material to be learned and that no facilitative effect for the brighter Ss was found in the Ausubel and Fitzgerald study because the material was already present in the S's response repertory but not yet present in the response repertory of the less capable Ss.

The studies cited above tend to indicate that familiarity of subject matter interacts with the type of instruction used. The notion of a subject variable interacting with a treatment variable would fall under the rubric of "Attribute-Treatment Interaction" or ATI. A recent review by Berliner and Cahen (1973) used TTI (Trait-Treatment Interaction) to categorize studies which are designed to produce these interactions.

The inconsistent and inconclusive results of earlier studies may have resulted from the failure to control for familiarity. The present study deliberately manipulated that variable. No study has been found which started with unfamiliar material and induced a degree of familiarity in Ss prior to their exposure to the program. The general purpose of this study was to produce familiarity x treatment interactions for achievement from programmed instruction under controlled conditions. Furthermore, this study examined these interactions immediately after completing the program as well as one week later.

Specifically, the purpose was to provide data that could explain some of the discrepant findings in the earlier studies. In addition, this study tested Tobias's (1973a) suggestion that prior familiarity with sub-

ject matter is a variable of importance in ATI research.

Hypotheses

The general hypothesis of this study was that, for PI, an S's prior familiarity with the subject matter to be learned significantly interacts with the response mode required of S.

Specifically, for groups who were and were not familiarized with the subject matter:

1. Constructed (overt) responses were not expected to result in differences in achievement.
2. Silent reading (covert) responses were expected to lead to superiority of the familiarization group.
3. Achievement for the familiarized covert group was expected to equal that of the overt response group.

This investigation used a factorial design, with familiarity and response mode as the two independent variables. The effects of these variables and the degree to which they interacted with sex and intelligence (for the junior high school group), assigned on the basis of I. Q. scores, was determined by multiple linear regression techniques, as suggested by Cronbach and Snow (1969).

Subjects

The experiment was essentially replicated with groups drawn from two distinct populations: 1) junior high school, 2) graduate students.

A total of 110 junior high school students, 60 of whom were female, was recruited from the Hebrew Institute of Rockland County and were either in the sixth (35), seventh (35), eighth (27) or ninth (13) grade. These Ss

volunteered to participate at the request of the prinicpal and were told that the purpose of the experiment was to study the way people learn.

A total of 60 Ss, 30 of whom were female, was recruited from graduate courses in educational research taught by the principal investigator at The City College of New York. Ss were asked to participate by the principal investigator and were told that the rationale, instrumentation, design, etc., of the study would be used as illustrative material during the course. Experience (Tobias & Abramson, 1970) had shown that college and graduate students who participate in research studies of this type do not necessarily do so with the purest of motives. The belief that Ss were deeply engaged in the experimental task and were really attempting to learn the material was found to be an over-optimistic assumption. It was felt that incorporation of the study into the instructional procedures of the course would lead to more highly motivated Ss. The Ss who volunteered, not all the enrolled students did, were told that the experiment was designed to study the different ways people learn from programmed instruction.

The junior high school and graduate students were paid six dollars for their participation.

Materials

The program used in this experiment consisted of a revised version of The Diagnosis of Myocardial Infarction (Mechner, undated), and had been revised and employed in a series of investigations at The City College of New York (Tobias, 1968, 1969a,b; Tobias and Abramson, 1970). Only the 89 frames consisting of technical verbal and technical pictorial content which Ss were unlikely to have been exposed to previously, were included in this study. A full description of the program, program scoring, posttest, post-

test scoring, reliabilities, etc., has been given elsewhere (Tobias, 1968).

The program was presented in standard LPI format, with the correct response to each frame given in the left margin of the following page. Ss were told to respond to each frame before turning the page to see the correct response. To insure that Ss could not see the answer through the page, a matter of some concern in earlier studies (Tobias and Abramson, 1970), the back of the left margin of each page was printed with random black "squiggles."

A separate reading version of the program which contained completed statements in each frame and did not require overt responses from the Ss was prepared for the reading condition.

Materials to familiarize the Ss with some of the technical vocabulary and ECG tracings were developed for this study (see appendix). Ten technical terms and five tracings were selected from the program for this purpose and were given to the familiarization groups at the start of their first session. Ss were not given any information as to the relationship between these materials and the program which was to follow.

Procedures

Two sessions were required to collect the data for this study. During the first session Ss were given either the LPI or reading version of the program after first completing a biographical questionnaire. This learning activity was immediately followed by a posttest. One week later the same posttest was readministered.

The graduate Ss were randomly assigned to the familiarization (F) or the non-familiarization (NF) condition. Half of the F and NF Ss were randomly assigned to the constructed response (CR) and half to the reading (R) condition. In the junior high school group, the 83 for whom I. Q. (Otis

Quick Scoring) scores were available were randomly assigned to F or NF, and CR or R after these data were subjected to a median split into high and low I. Q. scores. The other 27 junior high school Ss were randomly assigned to one of the four groups. Thus, at both levels there were Ss under each of the following conditions:

familiarization - constructed response (FCR),

familiarization - reading (FR),

non-familiarization - constructed response (NFCR),

non-familiarization - reading (NFR).

The Ss in the F condition were given the familiarization material before the program. They were given four minutes to copy a list of 10 vocabulary words twice and to memorize the list. No definition of the terms were given. They were then given two minutes to reproduce the list from memory. The Ss were then asked to study and match two groups of five tracings and to draw a copy of each tracing. Two minutes were allowed for these tracing tasks. Following these tasks the program was administered.

The CR and R groups were placed in separate rooms since the CR program generally takes longer than the R program. There were thus four separate groups, each in a different room. All Ss in each group began their version of the program at the same time. As each S completed his program, his work time was recorded and the posttest was given to the S; when S finished his test the time was again recorded and S was dismissed. Approximately one week later Ss were given the same posttest with each individual's time recorded.

Results

The critical measures in this investigation were the scores attained on the posttest (PT) and the delayed posttest (DPT). The scores on the tracing and the verbal sections were considered separately, yielding a total of four criterion measures for the junior high school and college groups.

The data were analyzed using multiple linear regression techniques, as outlined by Kelly, et. al. (1969). A subject's group membership was represented as a 0 for the CR group and a 1 for the R group. Similarly, the F group was coded as a 0 and the NF group as a 1. Interaction vectors between the experimental variables were the simple products of the component vectors. A preliminary analysis (1 way ANOVA) indicated that there was a differential sex effect in the junior high school ($F = 18.69$, $p < .01$) and college groups ($F = 4.73$, $p < .05$) on the PT tracing data. Therefore, a binary sex vector was added to the analysis with males coded 0 and females coded 1. The full model[1] for the analysis of the achievement data thus included the three main variables of response mode, familiarization, and sex and the four interactions between them.

The analysis followed a stepdown procedure which started with the full model and tested for the significance of any variable or interaction of interest included in the full model. The test was conducted by forming a reduced model through the removal of the component of interest and then testing for the reduction in the resulting multiple correlation. This procedure allowed for the estimation of the percentage of variance contributed independently by any variable adjusted for the effects of all other variables.

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[1]Beta weights, regression coefficients, and other data pertaining to the full models appear in Appendix B.

College Results

Table 1, the analysis of the college data, indicates that none of the main effects were consistently significant. Sex had a differential effect in favor of the males only on the PT tracing score ($F = 5.54$). Response mode and familiarization showed differential effects on the DPT tracing score ($F = 4.87$; $F = 7.85$ respectively), with the CR and the F groups scoring highest. These differences for only some but not all, the criterion scores were paralleled by the inconclusive findings of the earlier studies that prompted this investigation.

On the other hand, Table 1 clearly supports the main hypothesis of this study that response mode would interact with prior familiarity. On three of the four criterion measures (PT tracing, DPT tracing, DPT verbal) there was a significant response mode x familiarization interaction, and the interaction approached significance on the fourth criterion (PT verbal). On the PT and DPT verbal scores there was also a significant response mode a familiarization x sex interaction. Following the suggestions of Berlin and Cahen (1973), the interaction data are presented in both tables and figures. Table 2 shows the means and SDs for each group on the four criteria.

There was a significant response mode x familiarization interaction on the PT tracing and the DPT tracing. Figure 1 is a representation of the interactions resulting from the plotting of the means of the PT and DPT tracing scores. Clearly, familiarization affected the two response mode conditions differently. On the PT, prior familiarization resulted in a relatively high criterion mean for the Ss in the reading condition. For the CR group, familiarization led to a criterion mean a little lower than under the no familiarization condition. On the tracing retention measure, the

TABLE 1

Multiple Linear Regression Analysis of College Achievement Data

		Posttest				Delayed Posttest			
		Tracing		Verbal		Tracing		Verbal	
Effect	df	% Var.	F	% Var.	F	% Var.	F	% Var.	F
Response Mode (A)	1		a	.02	1.51	.07	4.87*	.02	1.09
Familiarization (B)	1	.04	2.63	.02	1.51	.11	7.85**		
Sex (C)	1	.09	5.54*	.04	2.55	.04	2.99[b]		
A X B	1	.07	4.52*	.05	3.06[b]	.21	14.76**	.12	7.85**
A X C	1			.10	6.22*			.06	3.67[b]
B X C	1			.07	4.31*	.02	1.65	.04	2.48
A X B X C	1			.09	5.31*			.14	9.23**

[a] F values less than 1 not shown

[b] $p < .10$

* $p < .05$

** $p < .01$

TABLE 2

Means and Standard Deviations for the College Ss on the Verbal and Tracing Posttest and Delayed Posttest

		Posttest				Delayed Posttest			
		Verbal		Tracing		Verbal		Tracing	
Group	N	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
FCR	14	30.43	7.59	22.29	8.43	25.50	5.60	14.11	7.33
NFCR	15	29.33	8.84	24.13	10.36	25.33	10.93	24.17	9.82
FR	15	28.00	8.64	27.40	6.99	26.20	9.10	22.00	10.91
NFR	15	26.60	8.10	20.13	10.24	22.13	8.90	12.70	11.18

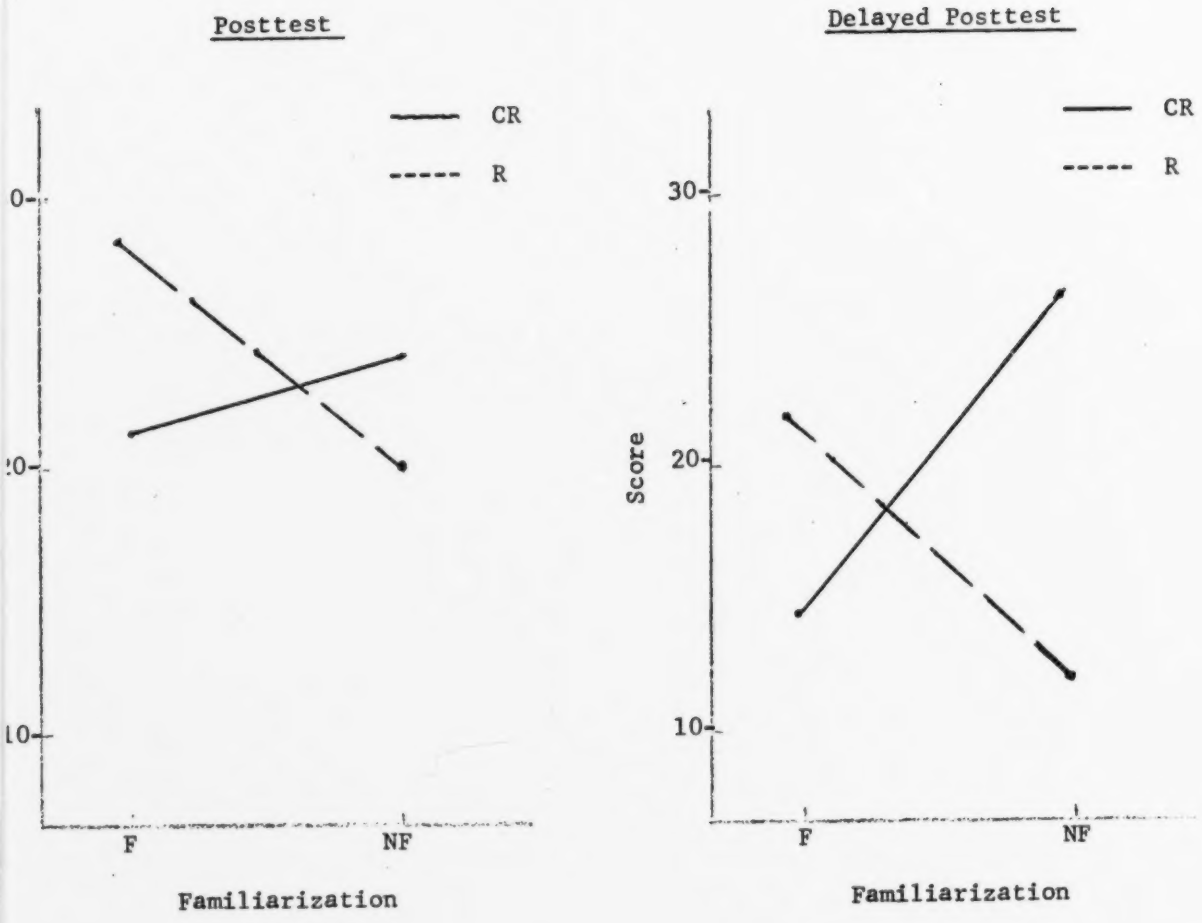

Fig. 1. Mean scores attained on the tracing portion of the posttest and the delayed posttest for College Ss.

DPT, prior familiarization had as strong a beneficial effect on the R group as it had a detrimental effect on the CR group.

There were significant triple interactions on the PT and DPT verbal criterion. Table 3 shows the means and SDs for the groups according to sex, and Figures 2 and 3 are pictorial representations of these data. For both males and females there was a response mode x familiarization interaction, but the interaction was different for each sex. The interaction for the males on the PT verbal criterion (see Fig. 2) was comparable to that generally found on the tracing data. Namely, familiarization led to increased achievement for the R group and to lower achievement for the CR group. There was an ordinal interaction for the females on the PT verbal score with the CR group higher than the R group under both familiarization conditions. On this criterion there was a significant increase in achievement under the F condition for the CR females.

The DPT verbal data diagrammed in Figure 3 exhibit an interaction comparable to that shown on the PT verbal scores, but the differential effects on the DPT of familiarization are more pronounced in the R group than on the PT verbal scores. The male NFR group performed more poorly than any other group while the male FR group had the highest achievement. The female CR groups exhibit the same effects of familiarization as on the PT verbal score, but now the NFR group scored higher than the NFCR group, producing the typical disordinal interaction shown in the other data (see figs. 1 and 2).

Junior High School Results

The same type of analysis was done on the junior high school data. When the multiple regression was performed on all 110 Ss there were few significant effects. A median split on the scores of the 83 Ss for whom

TABLE 3

Means and Standard Deviations for the College Males and Females on the Posttest and Delayed Posttest Verbal Scores

	Males					Females				
		Posttest		Delayed Posttest			Posttest		Delayed Posttest	
Group	N	$\bar{X}$	SD	$\bar{X}$	SD	N	$\bar{X}$	SD	$\bar{X}$	SD
FCR	7	27.00	8.52	24.14	6.87	7	33.86	4.98	26.86	4.06
NFCR	7	32.29	8.56	29.14	11.33	8	26.75	8.78	22.00	10.09
FR	7	32.29	4.07	31.14	6.07	8	24.25	10.04	21.88	9.39
NFR	8	27.13	8.81	18.63	9.69	7	26.00	7.85	26.14	6.31

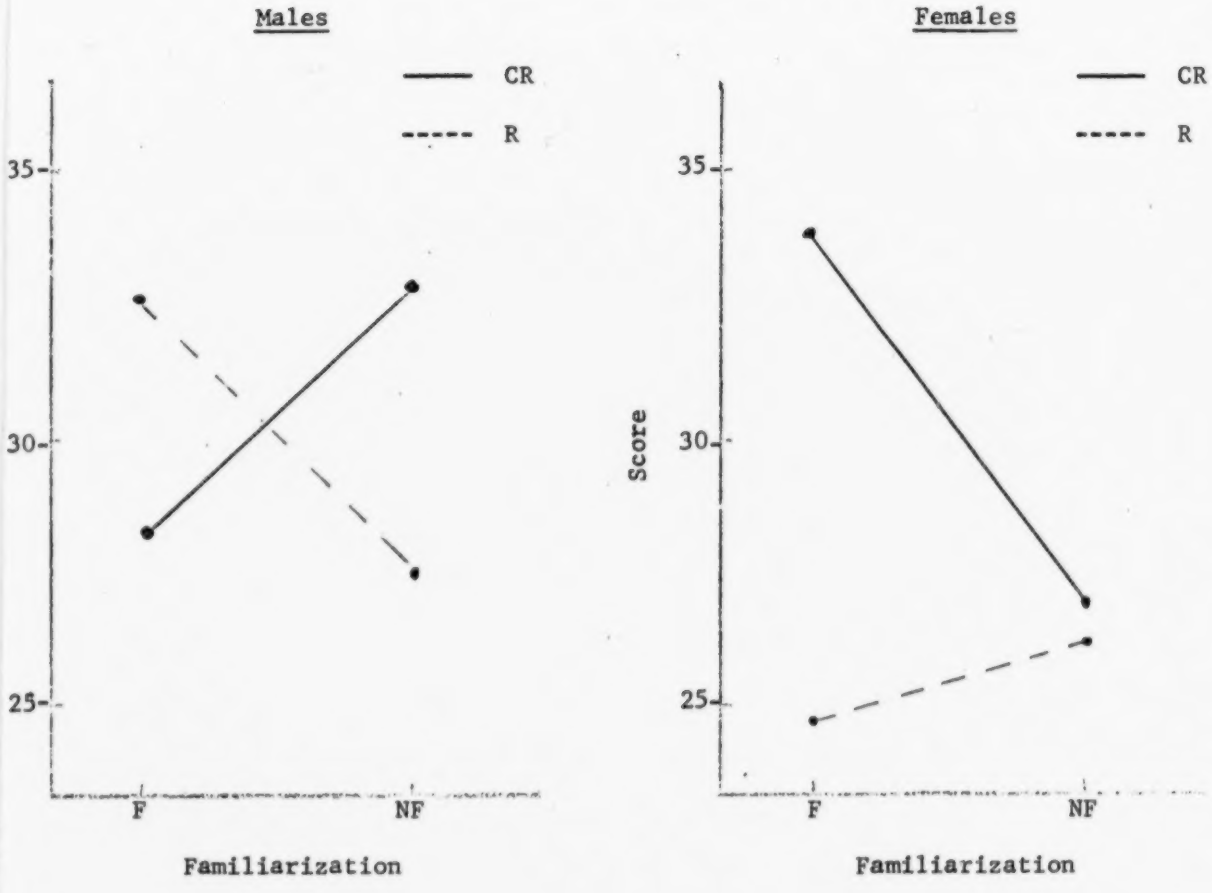

Fig. 2. Mean scores attained on the verbal portion of the posttest for male and female College Ss.

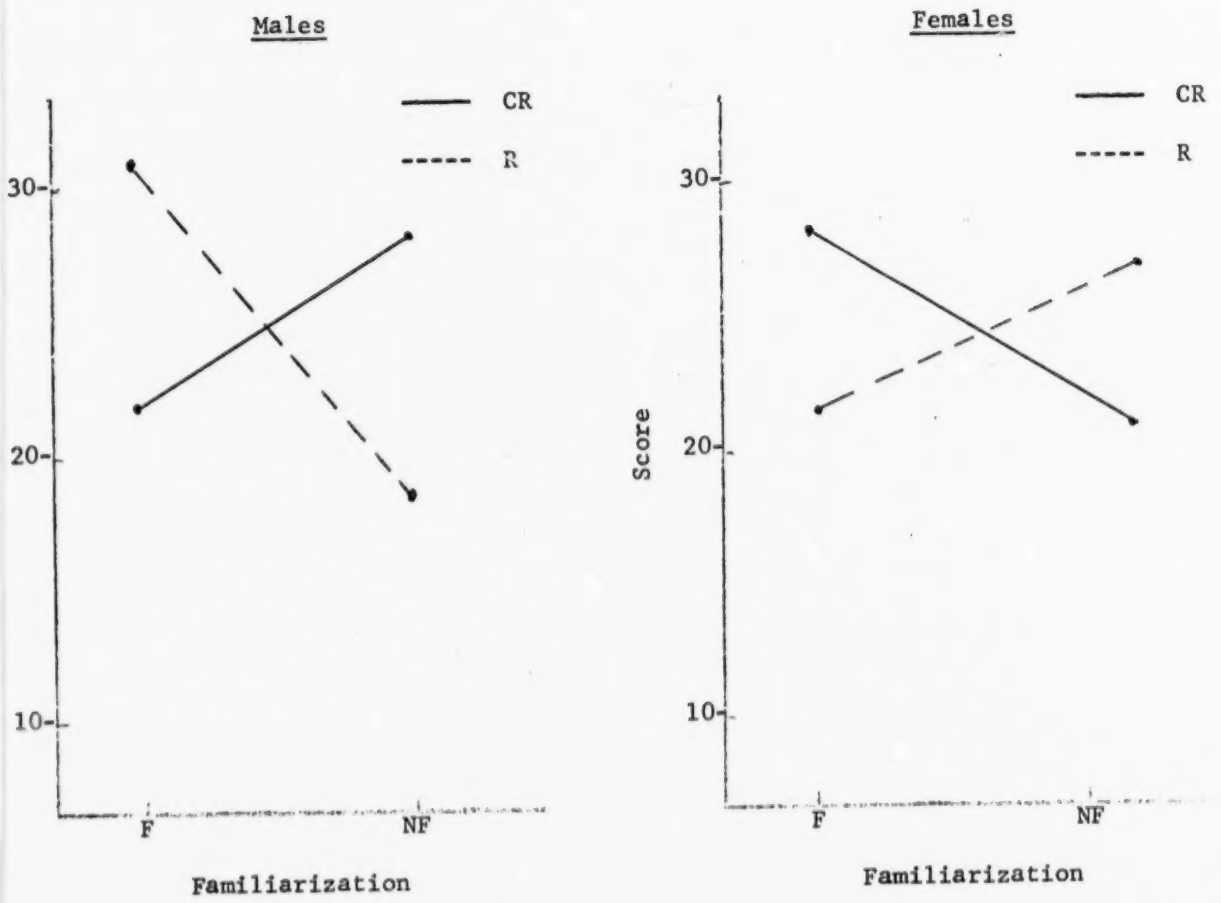

Fig. 3. Mean scores attained on the verbal portion of the delayed post-test for male and female College Ss.

I.Q. scores were available was used to divide the group into high (H) and low (L) I.Q. groups which were coded 1 and 0. A multiple regression analysis was then performed on the data for the 83 Ss with I.Q. included as a fourth factor. The original full model contained 15 separate elements: 4 main effects, 6 two-way interactions, 4 three-way interactions, and one four-way interaction. The stepdown procedure described earlier was applied, and the final full model containing only the terms that were significant in at least one instance and of importance to the study is shown in Table 4. The highly significant sex and I.Q. main effects on the PT and DPT criteria were due to the higher achievement of the girls and the H I.Q. group, respectively.

The hypothesized response mode x familiarization interaction was not present, but there were significant response mode x familiarization x I.Q. triple interactions on the PT tracing and the two DPT scores.

Table 5 lists the means and SDs on the verbal and tracing tests for the 83 junior high school Ss. Figures 4, 5, and 6 are representations of these data. The form of the response mode x familiarization interaction is the same for the H group on all three of the criteria. In each case, the familiarization material leads to higher achievement for the R group and lower achievement for the CR group. The L group had a different profile. The familiarization material always increased the achievement for the CR group, but fluctuated in its effect on the achievement of the R group. For the R group, familiarization increased achievement on the PT tracing while on the DPT verbal it decreased achievement and had no effect on the DPT tracing.

Time and Program Results

An analysis of variance was performed on the time data reported in

TABLE 4

Multiple Linear Regression Analysis of Junior High School Achievement Data

		Post-test				Delayed Post-test			
		Tracing		Verbal		Tracing		Verbal	
Effect	df	% Var.	F	% Var.	F	% Var.	F	% Var.	F
Response Mode (A)	1	.03	4.60*		a	.03	3.98*		
Familiarization (B)	1	.02	2.14	.01	1.27				
Sex (C)	1	.12	16.69**	.07	8.73**	.09	12.71**	.15	19.90**
I.Q. (D)	1	.22	31.89**	.25	31.46**	.29	42.14**	.18	24.26**
A X C	1	.05	7.18**	.03	3.78b	.01	1.91	.03	4.51*
A X B X D	1	.03	4.72*	.02	2.34	.07	10.07**	.07	9.52**
A X B X C X D	1					.03	3.63b	.01	1.38

[a] F values less than 1 not shown

[b] $p < .10$

* $p < .05$

** $p < .01$

TABLE 5

Means and Standard Deviations for the High and Low I.Q. Junior High School Ss on the Verbal and Tracing Posttest and Delayed Posttest

			Posttest				Delayed Posttest			
			Verbal		Tracing		Verbal		Tracing	
	Group	N	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
High I.Q. (>120)	FCR	12	24.67	7.42	20.83	10.74	18.50	7.56	17.29	11.65
	NFCR	9	26.44	8.67	28.72	9.49	24.67	8.47	29.11	7.12
	FR	9	23.44	7.67	27.94	8.18	25.11	6.33	24.33	7.65
	NFR	10	23.10	7.70	18.30	12.10	18.50	9.37	13.80	11.48
Low I.Q. (≤120)	FCR	13	19.54	6.77	19.31	12.24	17.92	7.14	11.69	8.90
	NFCR	9	14.33	8.33	11.11	11.76	13.44	4.45	8.11	9.57
	FR	11	15.91	5.00	10.18	7.25	12.73	4.00	6.86	8.67
	NFR	10	15.60	8.80	6.90	8.68	14.60	9.80	7.90	11.33

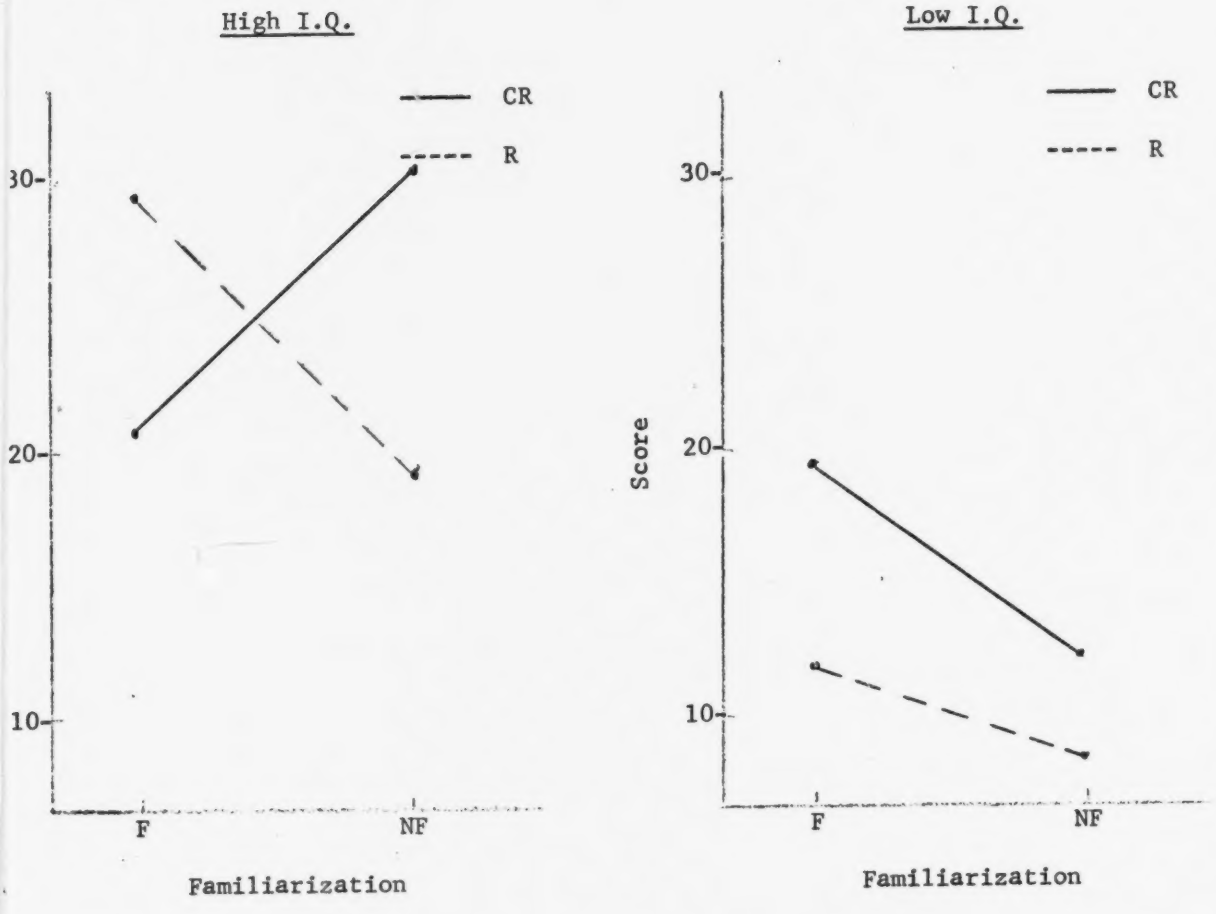

Fig. 4. Mean scores attained on the tracing portion of the posttest for high and low I.Q. junior high school Ss.

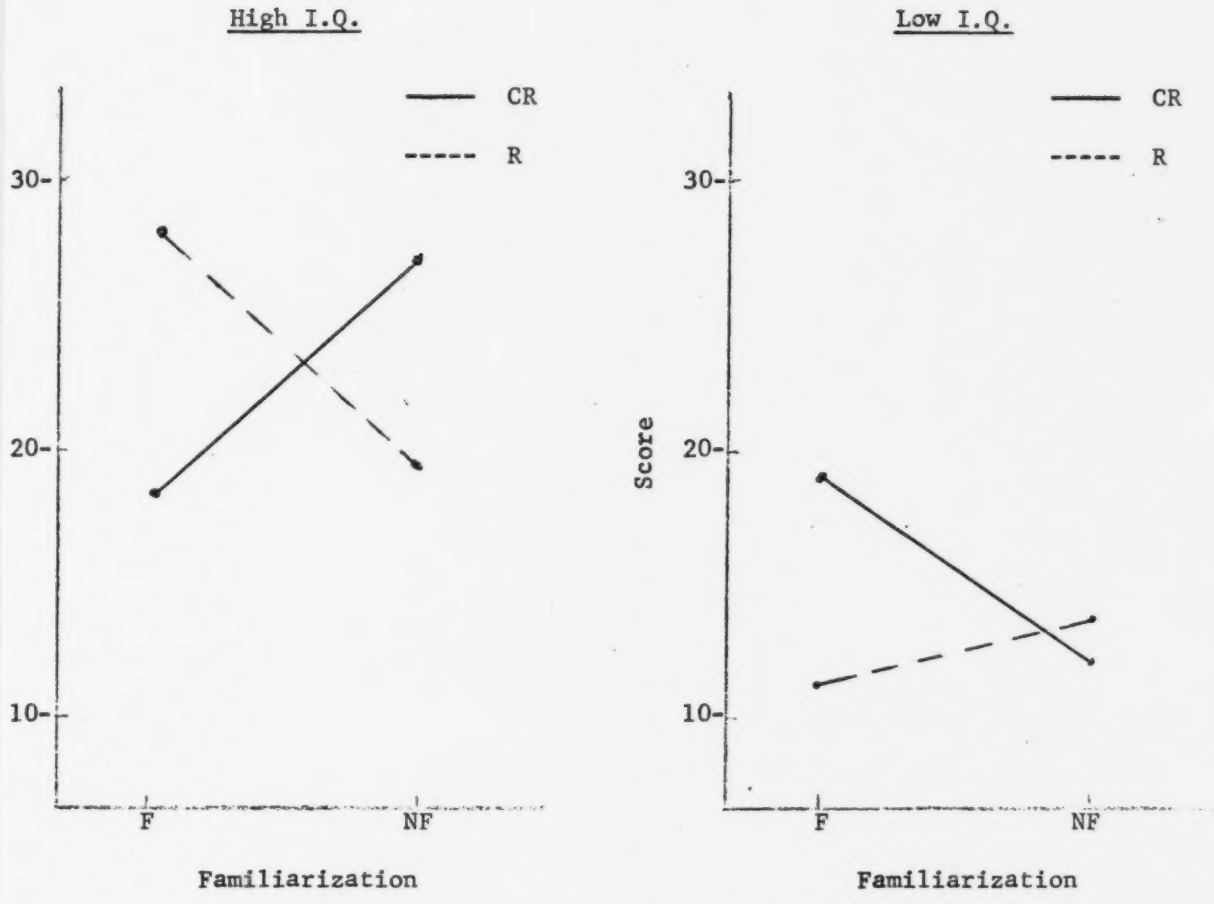

Fig. 5. Mean scores attained on the verbal portion of the delayed post-test for high and low I.Q. junior high school Ss.

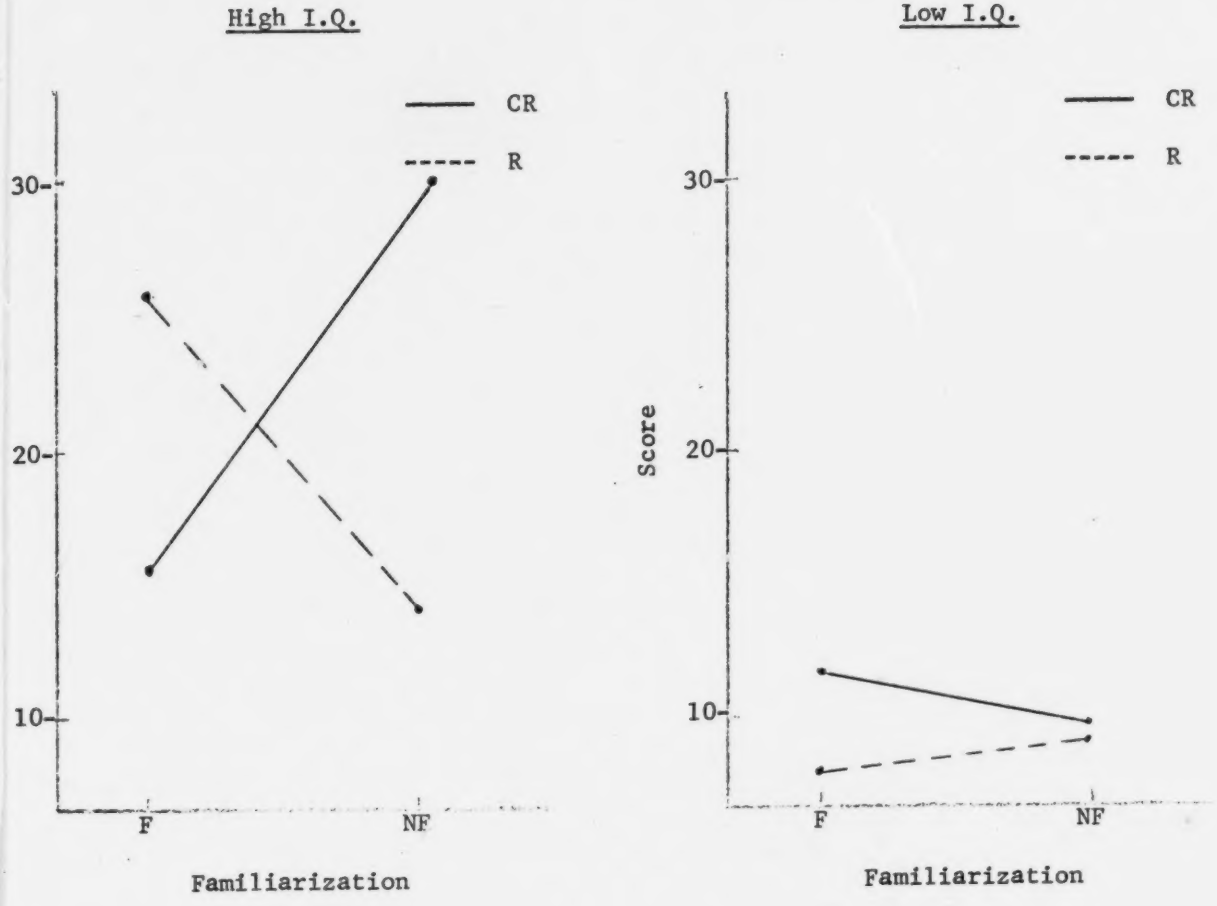

Fig. 6. Mean scores attained on the tracing portion of the delayed post-test for high and low I.Q. junior high school Ss.

TABLE 6

Mean Time in Minutes Spent by Ss in Completing the Program and Criteria Achievement Tests

	Junior High School		College	
	CR	R	CR	R
Program Time	72.67	24.04	72.00	25.77
Post-test Time	10.10	21.65	13.07	22.76
Delayed Post-test Time	10.85	10.78	12.69	12.17

Table 6. The analysis on program time showed an anticipated huge main effect for response modes for the college (F = 333.17) and junior high school (F = 1,326.03) Ss. Inspection of the data indicates that this was due to the relatively long time it takes to complete the CR program. The same analysis for the PT time showed another large effect for response mode for the college (F = 49.00) and junior high school (F = 135.66) groups with the CR group taking about half the time the R group spent on the test. This large effect disappeared on the DPT when there was virtually no difference between the groups.

Data for the percentage of correct responses to the program were available only for the two CR groups. These data, analyzed in the same manner as the achievement data, yielded no significant differences between the F and the NF groups for either the tracing or the verbal portions of the program. Both the junior high school and the college groups had 70-80% correct responses on the program.

The familiarization material for the two familiarization groups was also scored. In both the college and the junior high school groups, Ss scored better than 80% correct, implying that Ss did attempt to learn the familiarization material.

Discussion

The results of this experiment clearly support the main hypothesis of an ATI for achievement from programmed instruction between prior familiarity with material and response mode. However, not all of the interactions yielded the hypothesized results. Previous findings showing no main effect for response mode and a large difference for program time between response modes

were replicated. The implications of these data are discussed below.

College

The present results that constructing responses leads to superior achievement compared to achievement from a reading mode when the material is unfamiliar replicates previous findings (Tobias, 1969a, b; Tobias & Abramson, 1970), and provides strong experimental support for the position recently taken by Tobias (1973a) with regard to the familiarity interpretation.

The hypothesized ATI between prior familiarity and response mode was found for both verbal and tracing tasks but occurred most clearly on the tracing material. Familiarizing Ss with aspects of the tracing material prior to their exposure to the program led to superior achievement when the learning program followed a reading mode. This finding had been hypothesized before the study. However, the same familiarization led to lower achievement when the constructed response mode constituted the format of the program--an unexpected result as the hypothesis was for no difference between familiarized and unfamiliarized groups on the constructed response mode of the program.

The nature of the ATI was more complicated on the verbal material where there was a sex x familiarity x response mode triple interaction. Among males, the ATI had the same general form on the verbal material as the combined male and female group showed on the tracing material. That is, familiarization led to improved performance on the verbal material for the reading mode Ss and lower achievement for the constructed response Ss. The females had an opposite ATI: Familiarization led to higher achievement from the constructed response mode and lower achievement for the reading mode. The comparatively high scores achieved by the females in the non-familiarized reading condition (see Table 3) may have been due to the nature

of the Ss in that group rather than the treatment since the expected drop in achievement on the delayed test, administered one week later, was exhibited by every drop except the female non-familiar reading group.

Junior High School

Junior high school findings paralleled the college findings. There was fairly consistent triple interaction between familiarization x response mode x I.Q. The form of the familiarization x response mode ATI, however, was different for the high and low I.Q. groups.

The form of the interactions for the high I.Q. group replicated the interaction on the tracing material for the total group of graduate students and the interactions on the verbal material for the male graduate Ss. Here, too, the familiarization material had the same differential effects on response mode; it increased the achievement from reading and decreased the achievement from the constructed response mode. It should be noted that the high I.Q. group had a range of I.Q. scores from 121 to 160. It is not implausible to suggest that the high I.Q. group was most like the graduate student group, at least in terms of cognitive functioning, and therefore performed like their older counterparts.

The results of the low I.Q. group were quite different. Consistently, for this group, the highest scoring treatment group was the one which was both familiarized and received the constructed response program. In fact, for this group, achievement from the constructed response mode was always superior to that of the reading mode regardless of prior familiarization. For them, response mode was more influential than familiarization. This group had I.Q. scores ranging from 99 to 120 and compared to the general population should really be considered an above average I.Q. group rather than a low I.Q. group.

Time

In accord with the findings of other investigations, present results indicated that constructed response groups required significantly more time than the reading groups to cover the same material. A basic discussion of the efficiency issue has been given in an earlier study (Tobias & Abramson, 1970) and will not be repeated here. The important result, as pointed out above, was that the longer period of time and forced responding seemed to have adverse effects on achievement for Ss who were both good learners and who were familiar with the subject matter. The posttest time data support the "attention" interpretation of this finding. Ss who had the constructed response program, which required triple the time of the reading program, took about one-half the time to complete the posttest as compared to Ss who had the reading program. This test time difference did not result in differences in achievement since the high scoring constructed response group required the same amount of time as the low scoring group. Similarly, the reading groups required the same amount of time whether they scored high or low. It appears that Ss whose learning task took a long time (over an hour) raced through their test in order to finish their assignment. When the delayed test was administered, all the groups took equal time, indicating that the differential effect on the posttest time was probably due to the program that was given immediately preceding the test.

Response Mode

It had been hypothesized that familiarization would not affect achievement from the constructed response mode groups. A possible explanation for the unexpected finding that familiarization led to lower achievement from a constructed response mode than did non-familiarization follows a motivation-attention argument. For superior learners, such as the graduate stu-

dents and the high I.Q. junior high school students, it became counterproductive to elicit an overt response to every frame after previously familiarizing Ss with the material to be learned from the program. These high achievers might have become bored with the learning program when they were forced to respond to each frame whether they already knew the correct answer or not. This is particularly so in view of the inherent redundancy built into most linear programs. Thus, it was thought that the familiarized group was not as attentive as the non-familiarized group and thus did not learn as much. To test this interpretation the program and test time data were analyzed since time was assumed to be a function of attention and effort. This analysis proved fruitless as there were no differences between the familiarized and the non-familiarized groups on any of the time data (see Time section, pp. 25-26).

Furthermore, if, as suggested by Tobias (1973b), increased achievement from constructed response modes reported in the literature were only a result of more time spent on-task, then if time did not vary prior familiarization should not affect achievement. The time data in this study would tend to indicate that attention to the stimuli presented is at least as important as the absolute differences between CR and R time. Surely, brute writing time for the CR Ss cannot possibly account for the large differences in program time for the CR and R groups. In fact, it was found that it took approximately 32 minutes or less than half the CR time, to carefully write and trace all the required CR responses. It may be, that the time increase resulting from the physical requirement of responding to each frame is less related to subsequent achievement than is the time increase due to more reflective behavior on the part of the S as he proceeds through

the program. That is, time spent on a program should be thought of as time necessary to make the physical response plus the time required to attend and learn the material. Thus, it is entirely possible for two groups of Ss to take the same amount of time to complete a constructed response program and yet have different levels of achievement if the attention-time factor varied between the groups. Merely increasing total time spent on a task without affecting the attention-time would not increase achievement. Time factors aside, further research is warranted to explain the unusual reaction of high achievers to a constructed response program when they are already familiar with the material.

Sex

The sex difference in the direction of the constructed response x familiarization ATI at the college level was somewhat puzzling, especially in view of the attention-time argument given above. However, this finding may be understood in terms of the familiarity hypothesis and Maccoby's (1972) hypothesized male-impulsive and female-passive model of cognitive differences between the sexes.

The biographical questionnaires indicated that there were eight male and nine female science majors in the sample. However, in general, females in our culture have less exposure to and less interest in technical-scientific subject matter than do males. The type of subject matter of this experiment, myocardial infarction and its diagnosis (including analysis and reproduction of ECG tracings), was therefore probably more familiar or interesting to the males. Thus, the male response repertoire may have contained some of the information, even if, not necessarily the exact responses required by the program. The pre-familiarization may have taught the females just enough to increase their knowledge to the level of the repertoire of the

non-familiarized males. The females being more passive did not get "turned off" and continued to attend to the program until they completed their task. Thus, the constructed response pre-familiarized females, starting from the same level as the non-pre-familiarized males, achieved as well as the males who were given the constructed response program without pre-familiarization. Because the non-pre-familiarized females started at a knowledge level lower than their male counterparts, they ended up at a lower achievement level.

The girls at the junior high school level achieved more than the boys. This finding is in accord with Maccoby's hypothesis and may result from females giving greater attention to their task than males even when the task is of little interest to them.

Delayed Posttest

An interesting finding of this study was that the relative differences in the amount of learning as measured on the immediate posttest became more pronounced on the retention test. For the college group, the interactions on immediate learning accounted for 7% and 5% of the variance while on the retention test, administered one week later, the interactions accounted for 21% and 12% of the variance. The sharpening of achievement differences on the retention test is consistent with Ausubel's theory of meaningful learning (Ausubel, 1968). Ausubel proposed one mechanism, assimilation, to account for both learning and forgetting and concluded that retention was a direct effect of initial learning. Ausubel's assimilation theory states that the most important factor for learning and consequently for retention, is the prior presence of clear, stable, relevant ideas to act as anchors for the new material. Ausubel suggested that advance organizers should therefore be provided. The familiarizing material in this study may have acted as an organizer, providing the necessary anchors and allowing the

material to be more completely incorporated into the learner's cognitive structure. The data from this study, showing that the differences in performance increased during the retention interval support this theoretical position. There was a differential rate of forgetting; Ss who learned more initially forgot less than Ss who did not initially learn as much.

Implications and Conclusion

Although the present results clearly support a familiarization x response mode interaction, the data do not permit a clear and consistent theoretical interpretation of these interactions. However, the results of the study have implications for instructional methodology. Above average junior high school students and college level females who are to learn technical unfamiliar material similar to that employed in this study from a program, should first be provided some familiarizing material and then given the complete program requiring constructed responses. On the other hand, for superior junior high school Ss and college level males the optimum strategy requires the instructor either to implement a constructed response program without prior familiarization or to provide familiarizing material followed by a reading program. The latter option would require less time and thus increase available instructional time. If the students are already familiar with the material then a reading program would be most beneficial. In any event, Bracht (1970) notwithstanding, this study provides data on the existence of ATIs, and their effects on achievement from programmed instruction.

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Appendix A

Pre-familiarization Material

Name _____

Programmed Instruction
Research Project

DO NOT TURN THE PAGE
UNTIL TOLD TO DO SO

Please copy the following words in the spaces provided and say them to yourself until you have memorized them. After four minutes you will be tested to see how many words you have learned.

1. coronary	_____	_____
2. deflection	_____	_____
3. electrode	_____	_____
4. anterior	_____	_____
5. precordial	_____	_____
6. ventricular	_____	_____
7. occlusion	_____	_____
8. myocardial	_____	_____
9. infarction	_____	_____
10. ischemia	_____	_____

DO NOT TURN THE PAGE UNTIL TOLD TO DO SO

Write all the words you can remember here. You may put them in any order.

1.

2.

3.

4.

5.

6.

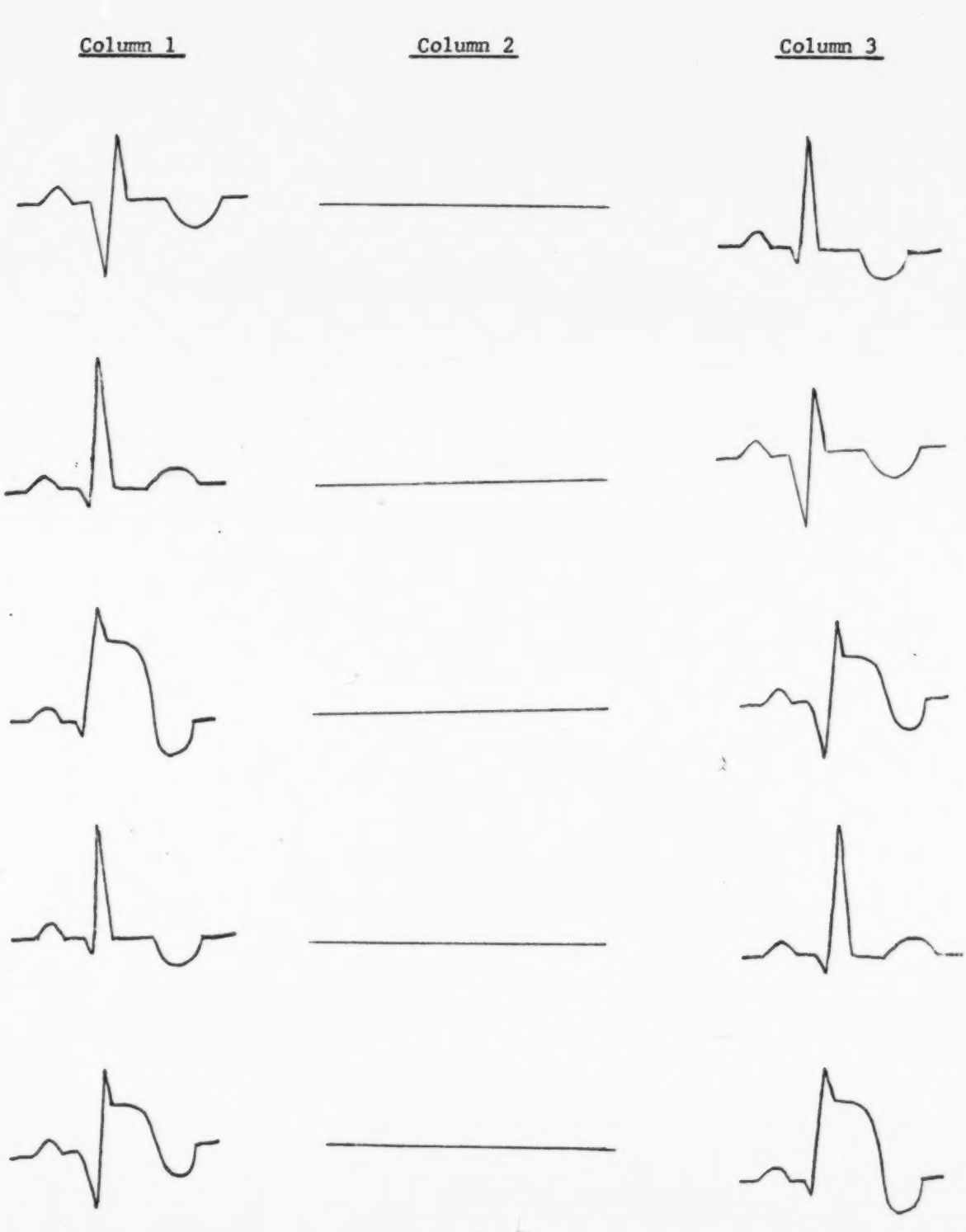
7.

8.

9.

10.

Copy the figures on the next page in the spaces provided in Column 2. When you have finished, draw a line connecting the figures in Column 1 with their matching figures in Column 3. You will be given two minutes for this task.


Column 1
Column 2
Column 3

Appendix B: Models

FULL POSTTEST TRACING MODEL COLLEGE 7 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	0.0285	9.4284	0.5118
RESPONSE MODE (RM)	-0.1518	6.5713	0.3567
SEX	-0.2770	0.9998	0.0542
FAM X RM	-0.2139	-14.3480	-0.6784
FAM X SEX	-0.1928	-8.1516	-0.3854
RM X SEX	-0.3154	-8.9194	-0.4217
FAM X RM X SEX	-0.2849	8.9908	0.3157

INTERCEPT = 21.7857

MULTIPLE $\underline{R}$ = 0.4560 MULTIPLE $\underline{R}^2$ = 0.2079 SE of ESTIMATE = 8.2662

SUM OF SQUARES = 1040.58 ERROR SS = 3963.44 TOTAL SS = 5003.73

DF OF NUMERATOR = 7 DF DENOMINATOR = 51 F = 1.91

FULL POSTTEST VERBAL MODEL COLLEGE 7 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	-0.0738	5.2855	0.3239
RESPONSE MODE (RM)	-0.1570	5.2855	0.3239
SEX	-0.1237	6.8569	0.4202
FAM X RM	-0.1402	-10.4462	-0.5575
FAM X SEX	-0.1545	-12.3926	-0.6614
RM X SEX	-0.2499	-14.8926	-0.7948
FAM X RM X SEX	-0.1151	19.3032	0.7651

INTERCEPT = 27.0000

MULTIPLE $\underline{R}$ = 0.4052 MULTIPLE $\underline{R}^2$ = 0.1642 SE of ESTIMATE = 7.5219

SUM OF SQUARES = 844.94 ERROR SS = 3281.58 TOTAL SS = 3926.53

DF OF NUMERATOR = 7 DF DENOMINATOR = 51 F = 1.43

FULL DELAYED POSTTEST TRACING MODEL COLLEGE 7 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	0.0112	8.7142	0.4026
RESPONSE MODE (RM)	-0.0905	10.1427	0.4686
SEX	-0.1798	-5.7857	-0.2673
FAM X RM	-0.3029	-23.4195	-0.9425
FAM X SEX	-0.0043	2.8839	0.1160
RM X SEX	-0.1572	-3.8570	-0.1552
FAM X RM X SEX	-0.1801	7.3212	0.2188

INTERCEPT = 17.0000

MULTIPLE $\underline{R}$ = 0.5293 MULTIPLE $\underline{R}^2$ = 0.2801 SE OF ESTIMATE = 9.2577

SUM OF SQUARES = 1935.03 ERROR SS = 4970.89 TOTAL SS = 6905.93

DF NUMERATOR = 7 DF DENOMINATOR = 51 F = 2.83

FULL DELAYED POSTTEST VERBAL MODEL COLLEGE 7 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	-0.1219	4.9998	0.2863
RESPONSE MODE (RM)	-0.0714	6.9998	0.4009
SEX	-0.0830	2.7141	0.1554
FAM X RM	-0.1770	-17.5176	-0.8739
FAM X SEX	-0.0566	-9.8569	-0.4917
RM X SEX	-0.0610	-11.9819	-0.5977
FAM X RM X SEX	0.0573	26.6425	0.9871

INTERCEPT = 24.1429

MULTIPLE $\underline{R}$ = 0.4462 MULTIPLE $\underline{R}^2$ = 0.1991 SE OF ESTIMATE = 7.8773

SUM OF SQUARES = 895.08 ERROR SS = 3599.03 TOTAL SS = 4494.12

DF NUMERATOR = 7 DF DENOMINATOR = 51 F = 1.81

FULL POSTTEST TRACING MODEL JHS 15 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	-0.1286	-1.6655	-0.1362
RESPONSE MODE (RM)	-0.1886	-2.3618	-0.1937
SEX	0.2993	4.0061	0.3282
IQ	0.4594	5.9917	0.4914
FAM X RM	-0.0926	-1.4225	-0.1163
FAM X SEX	0.2386	2.7907	0.2286
FAM X IQ	0.0798	0.8113	0.0665
RM X SEX	-0.0733	-0.9097	-0.0740
RM X IQ	0.1125	1.3660	0.1121
SEX X IQ	0.0969	0.3896	0.0319
FAM X RM X SEX	-0.0294	-0.3870	-0.0314
FAM X RM X IQ	-0.2005	-2.4691	-0.2026
FAM X SEX X IQ	-0.0775	-0.3740	-0.0305
RM X SEX X IQ	0.1208	0.6431	0.0527
FAM X RM X SEX X IQ	0.0414	1.6412	0.1344

INTERCEPT = 18.0498

MULTIPLE $\underline{R}$ = 0.7250 MULTIPLE $\underline{R}^2$ = 0.5257 SE OF ESTIMATE = 8.4416

SUM OF SQUARES = 6478.15 ERROR SS = 5843.44 TOTAL SS = 12321.60

DF NUMERATOR = 15 DF DENOMINATOR = 67 F = 4.95

FULL POSTTEST VERBAL MODEL JHS 15 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	-0.0930	-0.7351	-0.0854
RESPONSE MODE (RM)	-0.0715	-0.5779	-0.0673
SEX	0.2300	2.3310	0.2713
IQ	0.4992	4.3897	0.5115
FAM X RM	0.0113	0.0716	0.0083
FAM X SEX	0.2259	1.5877	0.1847
FAM X IQ	0.0180	0.3414	0.0397
RM X SEX	0.1008	0.8825	0.1019
RM X IQ	0.0136	0.2716	0.0316
SEX X IQ	0.0064	-0.2539	-0.0295
FAM X RM X SEX	-0.0215	-0.0512	-0.0059
FAM X RM X IQ	-0.1091	-1.2528	-0.1460
FAM X SEX X IQ	-0.0443	-0.0523	-0.0060
RM X SEX X IQ	0.0566	-0.2179	-0.0254
FAM X RM X SEX X IQ	-0.1146	-0.3258	-0.0379

INTERCEPT = 20.5914

MULTIPLE $\underline{R}$ = 0.6347 MULTIPLE $\underline{R}^2$ = 0.4028 SE OF ESTIMATE = 6.6675

SUM OF SQUARES = 2459.61 ERROR SS = 3645.42 TOTAL SS = 6105.04

DF NUMERATOR = 15 DF DENOMINATOR = 67 F = 3.01

FULL DELAYED POSTTEST TRACING MODEL JHS 15 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	-0.0002	-0.2170	-0.0183
RESPONSE MODE (RM)	-0.1423	-2.2258	-0.1883
SEX	0.2578	3.4258	0.2895
IQ	0.5007	6.6324	0.5611
FAM X RM	-0.1583	-1.6366	-0.1380
FAM X SEX	0.1611	1.3990	0.1182
FAM X IQ	0.0055	-0.1324	-0.0112
RM X SEX	0.0351	0.5277	0.0442
RM X IQ	-0.0280	-0.2902	-0.0245
SEX X IQ	0.1723	1.0287	0.0869
FAM X RM X SEX	0.0039	0.2472	0.0207
FAM X RM X IQ	-0.2372	-3.2597	-0.2759
FAM X SEX X IQ	-0.1034	-0.3662	-0.0308
RM X SEX X IQ	-0.0709	-1.6199	-0.1371
FAM X RM X SEX X IQ	0.0834	1.9574	0.1654

INTERCEPT = 14.9295

MULTIPLE $\underline{R}$ = 0.7299 MULTIPLE $\underline{R}^2$ = 0.5328 SE OF ESTIMATE = 8.1218

SUM OF SQUARES = 6169.55 ERROR SS = 5409.08 TOTAL SS = 11578.64

DF NUMERATOR = 15 DF DENOMINATOR = 67 F = 5.09

FULL DELAYED POSTTEST VERBAL MODEL JHS 15 Predictors

VARIABLE NAME	CORRELATION X VS Y	REGRESSION COEFFICIENT	BETA
FAMILIARIZATION (FAM)	-0.0308	-0.3760	-0.0457
RESPONSE MODE (RM)	-0.0690	-0.7343	-0.0895
SEX	0.3606	3.0927	0.3766
IQ	0.3956	3.7906	0.4621
FAM X RM	-0.0724	-0.5156	-0.0626
FAM X SEX	0.2106	1.6447	0.2002
FAM X IQ	0.0161	-0.1781	-0.0217
RM X SEX	0.0665	0.7156	0.0865
RM X IQ	0.0779	0.7260	0.0885
SEX X IQ	0.0663	-0.1343	-0.0163
FAM X RM X SEX	0.1232	0.9968	0.1205
FAM X RM X IQ	-0.2601	-2.3885	-0.2913
FAM X SEX X IQ	-0.0666	0.0843	0.0102
RM X SEX X IQ	-0.0397	-0.9822	-0.1198
FAM X RM X SEX X IQ	0.0221	0.8822	0.1074

INTERCEPT = 18.1760

MULTIPLE $\underline{R}$ = .6938 MULTIPLE $\underline{R}^2$ = .4813 SE OF ESTIMATE = 5.9391

SUM OF SQUARES = 2684.57 ERROR SS = 2892.39 TOTAL SS = 5576.96

DF NUMERATOR = 15 DF DENOMINATOR = 67 F = 4.14